FEEDING FARM ANIMALS

CHARLES WILLIAM BURKETT

THE

FEEDING OF FARM ANIMALS

BY

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RALEIGH:
Edwards & Broughton.
1902

TO MY FATHER.

PREFACE.

The purpose of this book is to present in a logical manner the more important factors that must be considered in the successful feeding of farm animals.

It is an effort to present the more important facts fundamental to the art of feeding.

The author has attempted, throughout the book, to present the truths of science in simple language, and to use only such technical terms as are absolutely necessary

It is to bring before the feeder and the student the simple scientific truths of nutrition and their practical application to feeding farm animals that this little book appears.

C. W. B.

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CHAPTER I.

FEEDING FARM ANIMALS.

The history of agriculture is simply the rise and progress of our race. In the ascent of man from the stages of savagery and barbarism, he associated himself with the tending of flocks and herds. The earliest stage of any agriculture was the pasturing of the subjugated animals. Man at first supplied his wants by killing wild animals and gathering fruits, the real natural products of the country. When this was no longer possible, animals were tamed and kept in herds. Cattle, sheep and goats were easily tended in this manner. In fact, to-day the nomads of Asia and South America practice agriculture in this pastoral way. At first there was an abundance of land for this purpose, but as soon as the population increased so that it encroached on this free practice, a higher system of agriculture followed. The Biblical accounts are very vivid in showing how the people fell to fighting when there was no longer room for people to wander at will. Later came the cultivation of forage crops; and we can only imagine what was cultivated during the most ancient times.

The early civilization of Egypt was rural in its nature, and the people became settled in their life and cultivated their natural meadows and raised crops for their horses and oxen, while the practice of raising various kinds of grains and roots was followed. It is the same in the history of Greece, Rome, England and continental Europe.

America presents a somewhat different agriculture. The red man had no domesticated animal save the dog and the squaw. Pasture lands belonged to the buffalo and the deer. Even with us, progress has been simple and slow. With the colonist, however, came the various classes of live stock; their increase has followed until to-day domestic animals are a fixed feature of every system 'of farming. Wild game for meat and clothing has disappeared, and so one of the great problems before every husbandman to-day is the production of meat and milk and wool and labor at the least cost.

He must know, therefore, not only what kinds of forage crops to produce, but he must know as well how to feed these crops to each class of animals in a scientific manner, so as to do it in an economical way.

NOTE PAGE FOR STUDENT'S USE.

CHAPTER II.

The Soil—The Plant—The Animal.

There is a close relation between the soil, the plant and the animal. One cannot exist without the others to fulfill its destiny within its name. A soil without plant or animal growth is barren, devoid of life, as shown by the great desert of Northern Africa.

Nature is simple in this relationship. First the soil with its many elements, and the air to furnish the fourteen that are present in the plant and animal. These elements are the very basis of plant and animal life. The body of the animal is made up of the identical elements found in the plant, yet the growth of the plant is necessary to furnish food for all animal life. The plant takes from the soil and the air the simple single chemical elements such as nitrogen, oxygen, hydrogen, carbon, phosphorous, sulphur, chlorine, potassium, sodium, calcium, magnesium, aluminium, iron and silicon, and with these builds up plant tissue, which, in its turn, is the food of the animal. The animal could not feed from the soil and air; it required the plant to take these elements and build them

into tissue first. From this plant tissue, the animal gets its food for maintenance and growth. Then the animal dies: with its decay and decomposition come the change of animal tissue back to the soil and air again—back to single simple elements that new plants may grow; that new plant tissue may be made for another generation of animal life. Thus the plant grows out of the soil and the air and the decay of animal and plant life to furnish food for the plant, that the plant may furnish food for the animal. Thus we see the cycle of life: from the soil comes the plant; from the plant comes the animal, and from the animal come the soil constituents.

The Farm and Animals.

A successful agriculture and the feeding of farm animals are dependent upon three conditions:

I. A soil rich in single simple elements for the free growth of plant life.

II. The adaptation of plant life to climatic and soil environments, so as to produce from the elements in the soil the largest growth of desirable plant life for animal food.

III. The feeding of animal life to produce

greatest growth and highest quality of meat and milk or wool and labor with the least expenditure of plant tissue.

The farmer, to make agriculture renumerative, must adapt himself to what falls within these three lines. He must enrich the soil. He must aid Nature in her efforts to change the unavailable plant food into an assimable form. Before the plant or animal died it was unavailable for plant food. The soil holds locked-up food in the same way. We see this same idea expressed in the method of preserving fruit and vegetables. A farmer's wife takes the tomato, for instance, and after preparing it, puts it in the tomato can and seals it up for the purpose of keeping it from decay and decomposition. Now that is the same way we have treated our soils: we have canned them up, so to speak, by taking out organic matter, by shallow plowing, and by carelessness in tillage, until these soils are hard and baked and dead to such an extent that air no longer enters freely, and consequently the unavailable plant food is not rendered assimable.

If we start the plow and turn it loose in these soils, and carefully and thoroughly till and cultivate and get organic matter back into

them by growing cow peas and clover, and adding manures, they will quickly change from their unproductive condition into the kinds that will produce remunerative crops. This matter of soil improvement is mentioned here because upon it successful husbandry and stock-raising rests. With a poor soil, we have poor crops or poor plant growth, which means poor livestock on the farm.

SOIL IMPROVEMENT AND STOCK RAISING GO HAND-IN-HAND.

The ideal agriculture maintains itself; therefore every system of farming should consist of both plant production and the feeding of animals. We see the importance of this proposition in three ways:

I. We need clover, cow peas, alfalfa and other legumes to build up the soil. But these are the very kinds of crops we want for horses, cattle, sheep and swine. We should grow these crops then to improve the soil and thereby get larger yields of grain, forage and grass crops to obtain plants rich in feeding constituents.

II. We need natural manures and fertilizers for improving the soil. The more livestock we have, the greater the quantity of manures pro-

duced. The commercial fertilizer bill is our greatest tax, and it is to a great extent unnecessary, for if business-like agriculture is followed, chemicals will be needed only to a limited extent. It should be our policy to purchase fertilizers in the form of feeding stuffs. Take a dollar and purchase your cotton-seed meal or bran or gluten, but instead of applying them direct to the soil as the source of nitrogen in the fertilizer, first feed them to livestock and get the value of the organized condition of the elements. The important difference between plant food or fertilizers and animal food or plants, lies in the fact that the plant takes the unorganized chemical elements and manufactures or builds them into organized tissue, which is the plant or the fruit of the plant. We can feed the plant or the fruit of the plant then to livestock, and get meal or milk or wool or labor from the organized tissue, and the animal returns to the soil the very chemical elements that the plant originally contained, only in a disorganized condition, which is the only way plants can use them for new growth. Thus the plant feeds the animal, the animal feeds the plant.

III. The animal changes raw materials into finished products. The feeder can take corn, grass, cow peas, clover, bran and cotton-seed

meal and make balanced rations for all classes of livestock. These are simply raw materials, which command the lowest prices when placed on the markets of the world. An increased value follows their change into a finished product. A dairy cow can be fed a mixture of twenty-five pounds of corn stover, cowpea hay and cotton-seed meal, which has a value of but ten cents and from that she will produce two pounds of butter worth fifty. The increased value is the result of the change from the raw material into the finished product.

NOTE PAGE FOR STUDENT'S USE.

CHAPTER III.

Constituents of Feeding Stuffs.

When the plant grows it makes use of the elements of the soil and the air. The plant itself is made up of myriads of cells, which continue to increase in number as the plant becomes larger. In a simple way the cell is an enclosed sac, holding within it the juices and other substances necessary for its enlargement and growth. The cell walls are made up of a woody substance called cellulose, which is thin and tender in green and growing plants, but becomes hard and woody as the plant matures. The roots, trunk, leaves and all other parts of the plant are made up of just these kinds of cells. Plant food in the soil becomes soluble in soil moisture and passes up through the roots to all parts of the plant. This soluble plant food in the cells is met by the carbon which also comes into the cells, not through the roots, however, but through the leaves, and thus we find all of the single simple elements in the plant cells ready to be made into plant tissue. These elements are not free to themselves when they are taken into the roots or leaves, but enter in different combined forms; oxygen

being the only one that, perhaps, is utilized in a small way in elemental form.

Building Plant Tissue.

The plant cells are responsible for the building of tissue and the formation of compounds in the plant or the fruit of the plant. Every live active cell contains protoplasm, the real life of the cell. When the soluble soil materials, which we call plant food, has been carried up through the long channels of cells, reaches the leaves, it comes in contact with the carbonic acid gas that entered the cells of the leaf through the mouths of the leaf, and there these various compounds are decomposed through the action of heat and sunlight and protoplasm and chlorophyl, with the effect of making a molecule of starch from the water and carbonic acid gas. Where the starch grains are found, some of them are changed by the protoplasm into sugar, which is readily soluble, to be transferred by diffusion from cell to cell, and left in those cells which need it most.

The formation of protein constituents is still more complex than starch. In a general way it may be said that starch or some starch derivative is united in the cells with the nitrates and sulphur that have been brought in the plant

from the soil. The protoplasm has, doubtless, broken up the nitrates in the active cells, mak- the latter able to unite with the starch, with the result that a protein compound is formed.

Fat is made from the same chemical elements that enter into the building of the starch grains. Starch is made from carbon, hydrogen and oxy- gen. Fat is made from the same elements, but has a large proportion of carbon and hydrogen and a small number of oxygen atoms. While all plants contain some fat or oil in their woody tissue, the great bulk of the oil or fat is built in the seed or fruit of the plant.

Protein is made from starch derivatives united with nitrates and sulphur, as explained above. Thus, we find that carbon, hydrogen and oxygen from the starch, and nitrogen and sulphur from the soil constituents enter into protein building.

THE MEANING OF PLANT-BUILDING.

Before the single simple elements were taken into the plant, they were of little value. The animal could not use them for food; they could not be burned to furnish heat; and they stored up no energy to carry on any of the world's work. What a change the plant makes of them, how- ever; these elements, without value in the soil

and air, when taken into the plant and built into tissue, at once become of vast importance. Primarily, they become the source of all animal food. Without them no animal life could exist, because animals either get their food from plants entirely or by eating other animals that depended for food upon plant life.

It must not be inferred from the above that starch, protein and fat are the only constituents found in the plant, neither should it be considered that they are the only important ones. This idea is common because of the complex nature of their building.

Other Constituents.

Ash is found in every form of plant life. One readily recognizes this constituent when burning takes place. The organized condition has been destroyed, and the ash remains. This goes to make up the bone material of the animal, and while the quantity is small, it ordinarily furnishes a sufficient quantity for bone and tissue structure in the animal. Sodium and chlorine usually are deficient in feeding stuffs, but are readily supplied in the form of common salt. Poor teeth, small and weak bones in children and domestic animals follow when not enough ash material is furnished in food. Va-

riation in food, and the use of coarse and roughage food usually corrects this condition. Water is always found in plants. The young growing plant contains often three-fourths of its weight as water, or more. Root crops contain even more; this explains to us why water in the soil is so important for the production of good crops.

The plant not only must have the water, but it is the only way for plant food to get into the plant. Water serves as a carrier for taking up through the roots all the plant food for the growth of the plant. Dew or rain on the plant, consequently, have no effect on the growth. The water must be in the soil, and enter the plant through the roots, carrying with it plant food that is in solution, and which can be distributed in the plant when it is needed.

Crude fiber serves as the framework of the plant. It is made of the same elements as starch and in a similar way. Young growing plants are tender because the crude fiber is tender. As the plant matures the fiber hardens, and becomes tough as we find it in hay, corn-stover or trees, etc.

From this explanation we are warranted in dividing plant constituents into the following classes:

I. Ash.
II. Water.
III. Nitrogen compounds or protein compounds.
IV. Nitrogen-free compounds.
   1. Starch.
   2. Crude fiber.
   3. Sugar, gums, etc.
V. Ether extract, or fat.

The reader will recognize readily now the relation between the plant and the soil. Instead of soil and air elements which the plant had to begin with, we see a different system of grouping. The several elements which have been grouped as ash, carbon, hydrogen, oxygen, nitrogen and sulphur are no longer considered as single elements, but now are known as protein compounds; likewise other atoms of carbon, oxygen and hydrogen have gone to build, some starch and fiber grains and others oils or fat. The plant is now produced ready to be used as food for the support of animal life.

SOIL AND AIR.	PLANTS.	ANIMALS.

CHAPTER IV.

THE DIGESTION OF FOOD.

Before the different constituents found in the plant, as explained in the preceding chapter, can be used for food for animals, they must be prepared for absorption into the system of the animal. This preparation takes place in the mouth, the œsophagus tube, the stomach, the intestines, aided by the various secretions incident to digestion and absorption.

Food is taken into the mouth, where it is masticated by means of the teeth, lips, cheeks, and the tongue. While the process of mastication is taking place, there is being poured into the mouth large quantities of saliva which softens the food and starts the process of digestion. The active principle of saliva is a soluble ferment called ptyalin that converts the starch of food into sugar. The amount of saliva that is poured into the food is very great, being often as much as one-tenth of the weight of the animal. This ferment is active after the teeth have been formed, which explains why it is not advisable to feed much starchy food to children before their teeth have begun development.

The food after being ground and mixed with

the saliva fluid goes to the stomach. With the horse and hog the stomach is a single sac, not capable of holding very large quantities of food; with the cow and sheep, on the other hand, we find a larger capacity for holding food and this is divided into four compartments—the rumen or paunch, reticulum, omasum, and the abomasum.

The first is simply a storehouse, where food is placed until it is thrown back to the mouth for further mastication.

This act is the popular idea of chewing the cud, and simply refers to rechewing the food, so as to get it finer and better ground for digestion. The food, after coming from the mouth the second time, passes either through the reticulum, or omasum, to the abomasum, or the true stomach, where the digestion continues. While in the stomach the saliva continues the digestion of the starchy matter, and is assisted by the gastric fluid that pours in from the lining of the stomach, which converts the protein or albuminoids into peptones. The fatty matter is not acted upon at this point.

There are three constituents of the gastric juice which effect changes in the food; pepsin, rennet and acid.

It should be noted here, also, that no secre-

tions enter the first three divisions of the ruminant's stomach, but only in the fourth or true stomach.

While food is in the stomach it is subjected to a constant churning movement that causes it to travel from the entrance to the exit or intestine. When it passes into the small intestine it is subjected to the action of the bile, and the pancreatic juices, which have principally to do with breaking up the fat compounds. Both resemble to a certain extent saliva in their ability to change starch into sugar. The secretion of the bile comes from the liver and the pancreatic juice from the pancreas or "sweet-breads," and both are poured into the intestine near the same point, so that they act together. The ferments they contain act in the following ways: changing starch into sugar, splitting fat into fatty acids, curdling milk, and converting protein compounds into soluble peptones.

This brief and general explanation shows us how digestion takes place. While all these fluids have been at work, and the food broken up by them, there has been no absorption in the system. Up to this point the food is really without the body; nor is there any entrance or

opening for it to get into the body save through the cells that line the whole digestive tract.

If we will go back a moment, we will recall that plant food was taken up through the roots through the cells when it was in a soluble state; in the same way the digested food, because it is broken up and soluble, readily diffuses through the cell walls that line the stomach and intestines, and is collected into the body system.

Circulation and Respiration in the Body.

As water in the plant is the carrier of plant food throughout the plant, so is blood the carrier and distributor of food in the animal. When food is absorbed, it either passes into the lymphatic system or the capillaries of the blood system. If in the former, it is carried to the thoracic duct, which extends along the spinal column and enters one of the main blood vessels. If collected by the capillary system, it is carried to the portal vein, thence to the liver, and finally to the heart, where it is poured, with the blue blood that has been collected from all parts of the body. At this point the blood contains both nutriment and the waste matter of the body. Before it can be sent through the body

system again, the waste matter must be renewed. This is accomplished by the heart forcing to the lungs the impure blood with its impurities collected from all parts of the body, and also the nutriment collected from the digestive tract. When the blood returns from the lungs to the heart it is free of broken-down tissue, but filled with oxygen and what nutriment that was previously absorbed into the system. There is seen here another relation between plant and animal function. When the plant was building tissue it released oxygen, exhaling it in the air, but took in through its leaves carbonic acid gas from the air. The animal when building tissue breathed in oxygen from the air but exhaled carbonic acid gas, thus giving to plant life what was needed for its growth and receiving in return what is necessary for its own nutrition and life.

What saliva does:

What the gastric juice does:

What the pancreatic juice does:

What the bile does:

CHAPTER V.

Conditions Influencing the Digestion of Food.

When a plant is young and tender it is agreeable to the taste of the animal. There is little woody tissue in this state of growth, which suggests a more favorable condition for digestion and assimilation in the animal system. Besides, it is reasonable to suppose an appetizing ration would be more readily appropriated than one which neither tempts the taste nor increases the appetite. Many a feeder owes his success to his ability in preparing the food placed before his animals in a wholesome and agreeable manner. Hunger will make animals partake of the food set before them, but nothing the feeder can do will make the same animals eat a quantity of unappetizing food sufficient for maintenance and profitable growth or milk production; and since growth and production result from food consumed it follows that flavor and taste are important, even though they add nothing to the energy or building capacity of a feeding stuff.

In a general way it may be said, also, that an animal will digest as high a per cent of food

eaten when it is eating its full capacity as when placed on but half the quantity it might be able to eat. Rapid growth and full milk flow therefore follow when the animal eats large quantities of food, showing again that palatableness is quite necessary for the most profitable feeding.

The Preparation of Feeding Stuffs.

Since the feeder is concerned in the highest digestibility of his feeding stuffs, he is interested in their preparation to produce the most economical returns. While it is true that many things can be done to increase the digestibility of feed, it does not always follow it is good business management to do so. For instance the grinding of food may mean the saving of eight or ten per cent, yet the labor of hauling to and from the mill and the cost for grinding may mean a less saving in the end. Every reader must determine these factors for himself for no set-and-dried rules will apply to all alike. Quite a number of feeding experiments have been made to determine the effect of grinding on the digestibility, and practically all have showed more or less marked gains. Ruminants, as a rule, are more likely to masticate their food in a thorough way. Yet the student knows that

many whole kernels of corn often are voided in the feces.

Steaming and Cooking Foods.

A great many devices are on the market for the preparation of materials for feeding the various classes of farm animals. The labor and expense connected with the practice is usually unwarranted and uneconomical.

Professor Jordan, discussing the matter, says: "The conclusions of German experimenters have been that these special treatments," such as wetting, steaming, cooking, and fermenting, "have no favorable influence, their effect being either imperceptible or unfavorable. The extensive trials by Kuhn and others with hay and bran ration, the bran being fed in several conditions, such as dry, wet, moistened some hours before feeding, treated with boiling water and fermented, gave results adverse to all the special methods of preparation as either useless or harmful, and no testimony so thorough and convincing has been furnished on the other side."

Early and Late Cut Hay.

Early cut hay is richer in protein and contains less crude fiber than that cut when in a more mature state. The increased weight due

to longer growth is chiefly in the substance cellulose. As the plant ripens, the more nutritious compounds go to the seed and leave the feeding part of the hay plant less valuable.

The best time for cutting hay is when the plants are in blossom; the nutritious compounds at this time are distributed more in the plants, and there is correspondingly less woody tissue.

Green and Dry Fodders.

A green fodder is no more digestible than the same forage carefully preserved by drying. The general impression that the opposite is true is doubtless due to the fact that much of the more valuable parts is lost in curing. This is especially true with clover and cow pea hays. The leaves readily break off in preparing for the stack or mow and much of the feeding value is lost.

Tables showing comparisons in preparation of feeds:

CHAPTER VI.

Composition of Animals.

There are a large number of different substances found in the animal body which may be grouped under four heads:

I. Water.
II. Ash, or mineral matters.
III. Protein.
IV. Fat.

We also found these same constituents in the plant with some additional substance like starch, sugar, gums, etc., that the chemist calls carbohydrates, thus making the grouping of plants as follows:

I. Water.
II. Ash.
III. Protein.
IV. Fat.
V. Carbohydrates.

So far as composition goes, then, the only difference between plants and animals is that the former contains carbohydrates, and the latter do not.

More than half of the entire weight of the

animal body is water. It is contained in all parts of the body, and is as essential for the development of solid tissue as any of the other ingredients. Young and growing animals, like young and growing plants, contain the highest per cent of water. As the animal matures, the proportion of water diminishes until it reaches about one-half the total weight.

The ash material, which is essential for bone and body tissue, amounts in the animal body to from two to five per cent of the live weight.

The supply of ash is especially needed for young and growing animals for bone development; serious consequences follow if the food stuffs do not supply the necessary ash ingredients. Protein in the animal is understood by the type as represented by the white of an egg or lean meat. The same chemical constituents are found here as in plant protein. The organic part of the bones, the skin, the internal organs, the brain and nerves—in short, all the working machinery of the body—are composed largely of protein.

Fat in the animal body is also made up of the same chemical elements as the fat of the plant. The quantity in the animal body varies in proportion to the condition of the animal as popularly expressed by being fat or lean.

What These Terms Mean.

From what has been said one readily sees that protein simply means that constituent of a feeding stuff, that when fed to an animal goes to furnish protein in the animal body, or in other words furnish the constituent to build up tissue, blood, brain and nerves, the internal organs, skin, etc., and to supply the waste in the body. Fat and carbohydrates on the other hand, because they do not contain nitrogen in their composition, cannot supply protein in the body; their work is to furnish fat in the animal body and heat and muscular energy.

Ash and water, being so simple and so easily supplied, will not require discussion or explanation here.

What These Compounds Do.

There is a continual breaking down of tissue in the animal; it requires protein to supply this. Every beat of the heart, every expansion of the lungs, every circuit of the blood, the secretion of digestive juices, all cause a waste or breaking-up of tissue, which must be constantly supplied if health is to follow. There must be a continual supply of protein to supply this waste. If the supply simply satisfies the waste, the weight of the animal will remain

unchanged. When the supply is liberal and exceeds the demands of the system, material may be stored in the body by the formation of fat or flesh and the animal will gain in weight.

Another necessity of food is to keep the animal warm. As wood is put in the stove to make heat, so food is taken into the animal system to furnish heat at an almost constant temperature. The carbohydrates and fat of food mainly supply heat constituents for the animal body. These same ingredients are the primary sources of fat and muscular energy in the animal system; yet protein often assists in this.

From this explanation we deduce the following:

Protein in food furnishes in the animal body—

1. Protein { Blood. Internal organs. Nervous system. Flesh, etc.
2. Heat.
3. Fat.
4. Muscular energy.

The fat of food furnishes in the animal body—

1. Fat.
2. Heat.
3. Muscular energy.

The carbohydrates of food furnishes in the animal body—

1. Fat.
2. Heat.
3. Muscular energy.

Tables showing composition of animal body :

CHAPTER VII.

THE DIGESTIBLE NUTRIENTS IN FEEDING STUFFS.

If all our feeding stuffs contained the proper proportion of digestible protein, digestible fat and digestible carbohydrates for the use and support of the body as well as for increase and growth, there would be no need of compounding rations for our various classes of farm animals. The feeding of no single feeding stuff will furnish the required quantities of the three important constituents; we need to combine them and in proper proportions to get economical and desirable results.

Before we are able to do this we must know the composition and the digestibility of the feeding materials. This has been determined by chemical analysis and digestive experiments of all the important feeding stuffs. The table following shows what is included in this:

TABLE I.

TOTAL COMPOSITION OF SEVERAL COMMON FEEDING STUFFS IN 100 POUNDS.

Feeding Stuff.	Percentage Composition.		Nitrogen-free Extract.	Ether Extract.
	Protein.	Crude Fiber.		
Corn stover—field cured	3.8	19.7	31.5	1.1
Cow pea hay	16.6	20.1	42.2	2.2
Red clover hay	12.3	24.8	38.1	3.3
Timothy hay	5.9	29.	45.	2.5
Cotton seed hulls	4.2	46.3	33.4	2.2
Corn-dest	10.3	2.2	70.4	5.
Wheat bran	15.4	9.	53.9	4.
Cotton seed meal	42.3	5.6	23.6	13.1
Cotton seed	18.4	23.2	24.7	19.9

This table shows the total number of pounds of each constituent in one hundred pounds of feeding stuff. We notice that the amount of protein varies from 3.8 pounds in corn stover to 42.3 pounds in cotton seed meal; likewise in respect to crude fiber, there are but 2.2 pounds of this constituent in corn, but 46.3 pounds of it in cotton seed hulls. The greatest variation is with nitrogen-free extract, which varies from 23.6 pounds in cotton seed meal to 70.4 pounds in corn. There is also much difference in the ether extract, as one notices but 1.1 pounds in corn stover, but as much as 19.9 pounds in cotton seed.

The student must not infer from this that all of these amounts are digested and assimilated in the animal body, on the contrary, only about half of the total constituents are digested. This gives rise to a study of digestibility in respect to the various food stuffs. Through a series of digestive experiments, the animal physiologist has determined the percentage of the various constituents, digested by farm animals.

Coefficients of Digestibility.

These various percentages are known in a scientific way by the term coefficients of digestibility. Without knowing these digestive coefficients, the feeder would be unable to ascertain the relative feeding values of the food stuffs at his command.

The table following shows the average coefficients of digestibility of the feeding stuffs given in the preceding table:

TABLE II.

Feeding Stuff.	Percentage Digestibility.			
	Protein	Crude Fiber.	Nitrogen-free Extract.	Ether Extract.
Corn stover—field cured	45	67	61	62
Cow pea hay	65	43	71	50
Red clover hay	55	46	64	53
Timothy hay	48	52	63	60
Cotton seed hulls	6	47	34	79
Corn-dest	76	58	93	86
Wheat bran	79	22	69	68
Cotton seed meal	88	32	64	93
Cotton seed	68	76	50	87

From this table we notice a decided variation in the percentage of digestible matter. Of the protein in cotton seed hulls, only six per cent is digested, while there is as much as 79 per cent of the ether extract or fat that is digestible.

Total Digestible Nutrients in a Feeding Stuff.

Since we have learned the composition of feeding stuffs and the percentage digestibility, we are in a position to consider the quantity of each constituent that is digestible in a feeding stuff. This is readily done by multiplying its composition by the coefficient of digestibility for each constituent.

For example, corn stover contains 3.8 pounds of protein, as seen by referring to Table I, of which 45 per cent is digestible, as shown in Table II, or 1.7 pounds of digestible protein in 100 pounds of corn stover.

The total digestible nutrients are determined in this way for each substance which gives rise to a third table showing the total quantities of nutrients in the several feeding stuffs.

TABLE III.

Feeding Stuff.	Total Digestible Nutrients in 100 Pounds.		
	Protein.	Carbohydrates.	Ether Extract.
Corn stover	1.7	32.4	0.7
Cow pea hay	10.8	38.6	1.1
Red clover hay	6.8	35.8	1.7
Timothy hay	2.8	43.4	1.5
Cotton seed hulls	0.3	33.1	1.7
Corn	7.8	66.7	4.3
Wheat bran	12.2	39.2	2.7
Cotton seed meal	37.2	16.9	12.2
Cotton seed	12.5	30.0	17.3

We have grouped crude fiber and nitrogen-free extract under one head in this table. They stand for the same thing in a feeding stuff and from now on, in the discussion of this subject, we will know the two considered together under the term carbohydrates.

Digestive Nutrients in Prominent Feeding Stuffs.

The composition and digestion coefficients have been determined for practically all of our feeding stuffs, consequently the making of rations is not a difficult problem. For this purpose the more common feeds, with their digestible nutrients, are given here in connection with the two subjects treated in this chapter. Those not given can readily be obtained from the publications issued by the U. S. Department of Agriculture. The list following contains the more common and important ones, or those the average feeder has to deal with under the ordinary feeding conditions. A column containing the dry matter in each 100 pounds of substance is also given, the importance of which will be seen in a succeeding chapter:

AVERAGE DIGESTIBLE NUTRIENTS IN AMERICAN FEEDING STUFFS *

Feeding Stuff.	Dry Matter in 100 Pounds	Digestible Nutrients in 100 Pounds.		
		Protein.	Carbohydrates.	Fat.
CONCENTRATES.				
Corn	89.1	7.9	66.7	4.3
Corn and cob meal	84.9	4.4	60.0	2.9
Gluten meal	89.6	9.0	61.2	6.2
Gluten feed	92.2	20.4	48.4	8.8
Wheat	89.5	10.2	69.2	1.7
Wheat bran	88.1	12.2	39.2	2.7
Wheat middlings	87.9	12.8	53.0	3.4
Rye	88.4	9.9	67.6	1.1
Barley	89.1	8.7	65.6	1.6
Oats	89.0	9.2	47.3	4.2
Rice	87.6	4.8	72.2	0.3
Rice hulls	91.8	1.6	44.5	0.6
Rice bran	90.3	5.3	45.1	7.3
Kaffir corn	84.8	7.8	57.1	2.7
Cotton seed	89.7	12.5	30.0	17.3
Cotton seed meal	91.8	37.2	16.9	12.2
Cotton seed hulls	88.9	0.3	33.1	1.7
Peanut meal	89.3	42.9	22.8	6.9
Soja bean	89.2	29.6	22.3	14.4
Cow pea	85.2	18.3	54.2	1.1
Linseed meal (new)	89.9	28.2	40.1	2.8
Brewers' grain (dry)	91.8	15.7	36.3	5.1
ROUGHAGE.				
Corn stover–field cured	59.5	1.7	32.4	0.7
Timothy hay	86.8	2.8	43.4	1.4
Soja bean hay	88.7	10.8	38.7	1.5
Oat straw	90.8	1.2	38.6	0.8
Red clover hay	84.7	6.8	35.8	1.7
Alfalfa hay	91.6	11.0	39.6	1.2
Cow pea hay	89.3	10.8	38.6	1.1
Pea vine straw	86.4	4.3	32.3	0.8
Corn ensilage	20.9	0.9	11.3	0.7
Crab grass	89.3	2.4	47.1	0.6
Cows' milk	12.8	3.6	4.9	3.7
Skim milk	9.6	3.1	4.7	0.8
Buttermilk	9.9	3.9	4.0	1.1
Oat hay	91.1	4.3	46.4	1.5

* U. S. Department of Agriculture.

Additional feeding stuffs:

CHAPTER VIII.

Some Scientific Terms in Feeding.

The student has now in mind something as to the meaning as well as the uses in the animal body of protein, carbohydrates and fat. The greater part of the practice of feeding is concerned with these three constituents, consequently they are deserving our most careful attention. The relation of one to the others in feeding problems gives rise to the several terms associated with the compounding of rations.

Nutritive Ratio.

If one knows the relative proportion of the nutrients of a feeding stuff, he is able to estimate to a certain extent its feeding value. This gives rise to the term nutritive ratio, which is simply the relation in quantity of the digestible protein to the digestible carbohydrates and fat. This ratio is determined by reducing the fat to its carbohydrate equivalent, then adding this to the quantity of digestible carbohydrates and dividing by the number representing the protein quantity.

Fat being more concentrated, so to speak, has a greater heat and energy value than the

carbohydrates. This difference is represented by the figures 2.4; that is, one pound of digestible fat is equivalent to 2.4 pounds of digestible carbohydrates.

Let us turn back to Table I and determine the nutritive ratio of corn stover. We see by the table that corn stover contains in each 100, 1.7 pounds of digestible protein, 32.4 pounds digestible carbohydrates and 0.7 pounds of digestible fat. We reduce the fat to its carbohydrate equivalent by multiplying it by the constant and authoritively-taken factor 2.4 and we get as the product 1.68, which means that 0.7 pounds of fat is equivalent to 1.68 pounds of carbohydrates to produce heat and energy. Now, since we have reduced the fat to carbohydrates we can add it to the total amount of carbohydrates which gives us 34.08 pounds of carbohydrates. This sum divided by number representing the protein 1.7 gives us the nutritive ratio or 20 pounds of carbohydrates for every pound of protein in that feeding stuff. In the form of proportion we have the following:

(1) Protein : carbohydrates : : 1 : x, or
(2) 1.7 : (32.4 x 1.68) : : 1 : x, or
(3) 1.7 : 34.08 : : 1 : 20 +.

This proportion is expressed, then, by saying the nutritive ratio of corn stover is 1 to 20.

Terms Applied to Rations.

When an animal is receiving the necessary quantities of protein, carbohydrates and fat, or the nutrients in proper proportions, its ration is "balanced".

Since no single feeding stuff contains the proper quantities of protein, carbohydrates and fat in a *balanced* way, the "compounding of rations" is necessary. This means the feeder gives certain quantities of different feeding stuffs in order to furnish the required amounts of nutrients to properly nurture farm animals. Referring to Table III the student notices that some foods are rich in protein, others low in protein and others high or low in carbohydrates and fat.

When a feeding stuff is high in protein and correspondingly low in carbohydrates and fat, it is said to be "narrow"; if it is the reverse to this, that is, low in protein and relatively high in carbohydrates and fat, it is "wide."

Feeding Standards.

In order to make-up rations for the various classes of farm animals, the student must know the quantity and the proportion of the nutrients to feed in the daily ration.

This question has been met by what feeding investigators call the feeding standard, which is simply a guide to show the quantities of nu-

trients to be fed. A dry dairy cow, for instance, does not require as large a quantity of protein, carbohydrates and fat as one in full flow of milk. We may say a dry cow is giving no milk and is at rest in the stall, therefore, requires little food. This is true, if it expresses the sense that she requires a quantity of digestible nutrients necessary for her maintenance. It should not be forgotten that work is going on all the time; the heart continues to beat, the lungs to expand, the digestive organs to secrete, and then fuel must be burned in the body to keep up the body heat—all this is the expression of work and constantly calls for food nutrients for repair material, heat and energy. If more food is furnished than is necessary for this maintenance of the body, the animal increases in weight. If too little food is given, then the reverse follows, and the animal loses in weight and becomes, in the popular expression "poor."

The feeding standard, being a guide, shows the feeder the quantities of each nutrient required in the body, not only for maintenance and support, but also for milk or beef, wool or mutton, and labor. It should be noted here that each class of animals requires a different standard. A cow that is giving but a small

amount of milk does not require as much digestible protein in her daily ration as one giving a heavy flow. Likewise a ration for fattening cattle is different from that given horses doing the farm work. It will be seen from this that the practice of feeding is not only an interesting art, but one that calls also for skill and training.

The table following is an example of feeding standards, showing the amount of dry matter and digestible nutrients required daily by farm animals per 1,000 pounds live weight:

WOLF-LEHMANN FEEDING STANDARD.

	Dry Matter.	Digestible Nutrients.		
		Protein.	Carbo-hydrates	Ether Extract.
Milch Cows—				
Cow giving no milk, at rest in stall	18.	.7	8.0	0.1
Daily milk yield 11 pounds	25.	1.6	10.0	.3
Daily milk yield 22 pounds	29.	2.5	13.0	.5
Fattening Cattle—				
First period	30.	2.5	15.0	.5
Second period	30.	3.0	14.5	.7
Third period	26.	2.7	15.0	.7
Sheep—Fattening—				
First period	30.	3.0	15.0	.5
Second period	28.	3.5	14.5	.6
Horses—medium work	24.	2.0	11.0	.6
Swine—Fattening—				
First period	36.	4.5	25.0	.7
Second period	32.	4.0	24.0	.5
Third period	25.	2.7	18.0	.4

As stated above, these standards are based on the weight of the animal being 1,000 pounds live weight. In case of animals weighing less, as sheep and swine, the quantity given should represent this proportion. A sheep, for instance, weighing 100 pounds would be fed just one-tenth the quantity represented in the feeding standard. A cow weighing 800 pounds would be given four-fifths of the quantity called for in the standard. In the same way if an animal weighs above the standard limit, then the quantity should be proportionally increased; a cow weighing, for instance, 1,100 pounds would be given one and one-tenth the amount called for by the standard.

In reference to feeding standards, Jordan says: "They are intended to apply to animals of average size, fed under normal conditions. They are not to be regarded as feeding receipts, but are to be varied according to circumstances. Small animals should receive proportionately more food than large ones; milch cows in proportion to the quantity and the richness of the milk; growing and fattening according to the rapidity of increase desired; work animals according to the severity of labor, and individual animals according to their individual needs."

NOTE PAGE FOR STUDENT'S USE.

CHAPTER IX.

The Compounding of Rations.

The animal uses food for five different and distinct purposes:

1. To replace the waste from all parts of the body.

2. To produce heat to keep the body warm.

3. To make growth or increase the body in muscle, fat, flesh, bone, etc.

4. To produce energy so that work may be done.

5. To produce milk, wool, etc.

The supply that furnishes the materials for the above named purposes comes from the food furnished by the feeder. We now understand this food material is expressed in terms of protein, carbohydrates and fat. These terms represent the digestible nutrients of a feeding stuff. To feed these nutrients in the quantity and proportion they should be fed for one or more of the five purposes cited above gives rise to the selection and compounding of feeding rations.

How a Ration is Made.

To show the method of making up a ration, let us begin by supposing we have a dairy

cow weighing 1,000 pounds and yielding about three gallons of milk daily. We could feed her three kinds of rations: one containing the roughage food raised on the farm, like straw, corn stover, cow pea hay, etc., or nothing but grain food, like cow peas, bran, cotton seed and cotton seed meal; or we could feed her a combination of these, that is, a mixture of coarse and grain feeds. This latter method is the most satisfactory, safest and economical. But how much roughage and how much grain shall we feed? Let us begin the making of the ration and see. What roughage shall we feed? Why, what we raise on the farm, of course. Here is corn stover, cow pea hay, timothy hay, clover hay, and a great many others, as the student will remember seeing on the page giving the digestible nutrients of our common feeding stuffs. That same table gives us all the data necessary for calculating how much feed should be supplied to both maintain the animal and furnish the milk-producing constituents.

For a trial ration, we decide to give 10 pounds of corn stover and 10 pounds of cow pea hay daily. By referring back to the table having the digestible nutrients of the various feeding stuffs we are able to proceed. We will take

the corn stover first: we find by the table that 100 pounds of corn stover contain:

59.5 pounds of dry matter.
1.7 pounds of digestible protein.
32.4 pounds of digestible carbohydrates.
.7 pounds of digestible fat.

If one hundred pounds of corn stover contain these quantities of digestible nutrients, then one pound contains just one one-hundredth or the following quantities:

Dry matter,	.595	pounds.
Protein,	.017	"
Carbohydrates,	.324	"
Fat,	.007	"

Ten pounds will of course contain just ten times the quantity of one pound, or the following quantities:

Dry matter,	5.95.
Protein,	.17.
Carbohydrates,	3.24.
Fat,	.07.

The digestible nutrients of cow pea hay is ascertained in the same way:

COW PEA HAY.

	In 100 Pounds.			In 1 Pound.		In 10 Pounds.
Dry matter,	89.3	÷ 100	=	.893	× 10	= 8.93
Protein,	10.8	÷ 100	=	.108	× 10	= 1.08
Carbohydrates,	38.6	÷ 100	=	.386	× 10	= 3.86
Fat,	1.1	÷ 100	=	.011	× 10	= .11

Arranging these in a table now for a comparison with the feeding standard, so as to know if we are feeding the correct proportions and quantities of nutrients, we have:

FIRST TRIAL RATION FOR DAIRY COW WEIGHING 1,000 POUNDS AND YIELDING THREE GALLONS OF MILK DAILY.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.			
		Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Ten lbs. corn stover	5.95	.17	3.24	.07	------
Ten lbs. cow pea hay	8.93	1.08	3.86	.11	------
First trial ration	14.88	1.25	7.10	.18	------
Feeding standard	29.0	2.50	13.00	.50	1:5.7

A glance at this table shows that the trial ration falls below in everything, consequently the quantities must be increased in order to meet as nearly as possible the standard, so as to furnish all nutrients for the animal and the production of milk.

To complete the ration, let us add 5 pounds of clover hay, 9 pounds of cotton seed hulls, 2 pounds of cotton seed meal and 1 pound of bran. The digestible nutrients are ascertained in the same manner as before, and a second trial made to determine if the additional feeding stuffs furnish the necessary nutrients and in a properly balanced form, as follows:

SECOND TRIAL FOR RATION FOR DAIRY COW.

Feeding Stuffs.	Dry Matter.	Digestible Nutrients.			
		Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Preceding rations—					
Ten lbs. stover } Ten lbs. cow pea hay }	14.88	1.25	7.10	.18	------
Five lbs. clover hay	4.24	.34	1.78	.09	------
Nine lbs. cotton seed hulls	8.00	.027	2.98	.15	------
Two lbs. cotton seed meal	1.83	.74	.34	.24	------
One lb. bran	.88	.12	.39	.03	------
Second trial ration	29.83	2.48	12.59	.69	1:5.7
Feeding standard	29.00	2.50	13.00	.50	1:5.7

This second trial ration meets the requirements in every way. The dry matter is but little in excess, which is of no importance. The deficiency in carbohydrates is met by the slight excess of fat, and the protein quite agrees with the standard. The nutritive ratio of our trial rations is the same as the feeding standard. From this we learn that 10 pounds of corn stover, 10 pounds of cow pea hay, 9 pounds of cotton seed hulls, 5 pounds of clover hay, 2 pounds of cotton seed meal and 1 pound of bran make a satisfactory ration for a dairy cow weighing 1,000 pounds and yielding about three gallons of milk daily.

RATION FOR DAIRY COW:

CHAPTER X.

The Compounding of Rations—Continued.

A RATION FOR THE BEEF ANIMAL.

The daily ration for the beef animal is determined in the same way. We start with a trial ration made from the common feeding stuffs grown on the farm; if these do not furnish the desirable nutrients, then it is economy to purchase what is needed in form of concentrates, or the grain foods.

We will choose for our trial ration 10 pounds of corn stover, 10 pounds of cow pea hay and 10 pounds of corn. Calculating the nutrients in these as we did in case of the dairy cow, we have:

Trial Ration for Fattening the Beef Animal Weighing 1,000 Pounds.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.			
		Protein.	Carbohydrates	Fat.	Nutritive Ratio.
Ten lbs. corn stover	5.95	.17	3.24	.07	------
Ten lbs. cow pea hay	8.93	1.08	3.86	.11	------
Ten lbs. corn and cob meal	8.49	.44	6.00	.29	------
Trial ration	23.37	1.69	13.10	.47	1:8.4
Feeding standard	30.00	2.50	15.00	.50	1:6.5

A glance at this trial ration shows that there is too little of every nutrient. There are almost enough fat and carbohydrates, but the protein shows considerable difference between the standard and what we have. We must, therefore, balance the ration with a feeding stuff high in protein in proportion to the other nutrients. We can find such a feeding stuff in cotton seed meal, of which we will use 2 pounds.

SECOND TRIAL RATION FOR THE BEEF ANIMAL WEIGHING 1,000 POUNDS.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.			
		Protein.	Carbohydrates.	Fat	Nutritive Ratio.
Preceding ration— Ten lbs. corn stover Ten lbs. cow pea hay Ten lbs. corn and cob meal	23.37	1.69	13.10	.47	1.84
Two lbs. cotton seed meal	1.83	.74	.34	.24	------
Second trial	25.70	2.43	13.44	.71	1:6.2
Feeding standard	30.00	2.50	15.00	.50	1:6.5

Our second trial shows that we are still below in dry matter, protein and carbohydrates, though the fat is a little high. A feeding stuff, containing a little more dry matter and carbohydrates, and proportionally lower in protein and fat, will give us nearly a balanced ration. Let us use 4 pounds of cotton seed hulls and we will have:

Third Trial Ration for the Beef Animal Weighing 1,000 Pounds.

Feeding Stuff.	Dry Matter.	Digestible Nutrients. Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Preceding ration— Ten lbs. corn stover, Ten lbs. cow pea hay, Ten lbs. corn, Two lbs. cot'n seed meal	25.70	2.43	13.44	.71	------
Four lbs. cotton seed hulls	3.55	.02	1.32	.06	------
Third trial ration	29.25	2.45	14.76	.77	1:6.7
Feeding standard	30.00	2.50	15.00	.50	1:6.5

This third trial ration shows a fairly close agreement of the nutrients to the feeding standard. The substitution of a half pound of cotton seed meal for a half pound of corn and cob meal would make the ration conform almost exactly with the standard.

We can say, therefore, that a ration consisting of 10 pounds corn stover, 10 pounds cow pea hay, 10 pounds of corn and cob meal, 2 pounds cotton seed meal and 4 pounds of cotton seed hulls furnish all the required nutrients for fattening the beef animal.

Errors in Feeding Beef Cattle.

It is a common practice in many sections of the country to depend rather exclusively upon

products raised in these special sections for fattening cattle. For instance, the farmer in the middle west raises corn in immense quantities and depends upon grass, corn stover and corn for growing and fattening purposes. All of these products are low in protein in proportion to carbohydrates and fat. Likewise the Southern farmer uses products that are not readily balanced alone. The use of cotton seed, cotton seed meal and cotton seed hulls is neither heathful for the animal fed, nor an economical practice for the feeder.

The Western farmer fails to get the most satisfactory gains because the food products used contain too little protein in proportion to the carbohydrates. The Southern farmer feeds too little of the carbohydrates in proportion to the protein, and likewise gets unsatisfactory gains even by feeding an expensive product.

Let the student try to make up a feeding ration consisting of either corn stover and corn or cotton seed meal and hulls and he will soon see how impossible it is to meet the standard.

It becomes an easy matter on the other hand to make balanced rations by interchanging the food stuffs mentioned above. Not only does the change make better returns in the growing or fattening animal but is more cheaply done.

RATION FOR FATTENING CATTLE:

CHAPTER XI.

THE COMPOUNDING OF RATIONS—Continued.

RATION FOR THE HORSE.

The general facts which have been presented in relation to the practice of making rations are as applicable to horses as to bovines.

A balanced ration is just as important to the horse as to any other class of farm animals. Corn, oats and timothy hay are the feeding stuffs universally used. Experiments have shown, however, that any feeding stuff or combination of feeding stuffs furnishing the proper quantities of digestible nutrients can be used in feeding horses. The kind and quality of digestible nutrients contained in feeds, and not their names, should guide in the preparation of rations for horses.

THE HORSE USES LESS ROUGHAGE.

A basic principle of ration-making for horses is the use of a relative smaller quantity of roughage and a correspondingly larger quantity of concentrates than used for bovines. This is a physiological principal due to the size of the horse's stomach. In treating this subject

it is necessary to consider the storage capacity of the horse so as not to provide too large quantity of roughage in the ration.

With this explanation we are ready to make up a feeding ration, and this is done in the same manner as for dairy and beef animals.

RATION FOR FARM HORSE DOING MODERATE WORK AND WEIGHING 1,000 POUNDS.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.			
		Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Four lbs. gluten feed	3.80	.81	1.92	.32	------
Four lbs. corn stover	2.40	.07	1.20	.02	------
Four lbs. corn and cob meal	6.80	.35	4.80	.23	------
Eight lbs. cow pea hay	7.20	.96	2.72	.08	------
Total	20.20	2.09	10.64	.65	1:6+
Feeding standard	24.00	2.00	11.00	.60	1:6.2

VARIOUS FEEDS CAN BE USED IN RATIONS FOR HORSES.

Corn, oats and timothy are not the only feeds for the horse. It is the writer's judgment that a ration made of the ordinary feeding stuffs of the farm, if properly compounded so as to furnish the required quantities of protein, carbohydrates and fat, any one or all of the feeds in the proverbial ration can be discarded. In fact, at present prices, the farmer can afford to sell

oats and timothy which he is now using in his horse rations and in place use corn stover, cow pea hay and purchase cotton seed meal, gluten, dried blood, or any of the by-products and can do this with confidence that he will be able to maintain his farm horses in proper flesh and good health and mettle.

FEEDING STUFF FOR THE HORSE.

Roughage.	*Grains in Concentrates.*
Timothy.	Corn.
Clover.	Oats.
Cow pea hay.	Barley.
Silage.	Cotton seed meal.
Alfalfa.	Linseed oil meal.
Roots.	Dried blood.
Oat straw.	Tankage.
Corn stover.	Gluten meal and feed.
Wheat straw.	Cow peas.
Soja bean hay.	Soja beans.

Selecting from a list like the above, the greater part of which can be raised on the farm, there is no reason why the cost of feeding farm horses should be greater than other classes of farm animals.

RATION FOR HORSE—MODERATE WORK.

CHAPTER XII.

FEEDING YOUNG ANIMALS.

Young animals require different food from growing or mature ones. Nature's method of feeding is with milk, which contains the necessary nutrients in proper balanced form.

Protein is required in greater quantity at time of birth in proportion to the quantity of fat and carbohydrates than at any other time. As an illustration of this, let us take the analysis of a cow's milk when a calf is just born and at a little later period.

COW'S MILK—100 POUNDS.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.		
		Protein.	Carbohydrates	Fat.
Colostrum	25.4	17.6	2.7	3.6
Cow's milk	12.8	3.6	4.9	3.7

A glance at this table shows that the first milk contains large quantities of the "muscle formers" and a small quantity of the "heat formers." In a short time there is a marked change. The protein has been diminished and the carbohydrates increased. This change takes place gradually but in a way to furnish just the

nutrients necessary for most rapid growth. In other words, as the animal grows older the feeding rations becomes wider, which means a relatively smaller amount of protein in proportion to the carbohydrates and fat.

This is illustrated in the following table of feeding standards for growing dairy cattle.

TABLE BASED ON BASIS OF 1,000 POUNDS LIVE WEIGHT. (JORDAN.)

Live Weight Calf.	Dry Matter.	Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
150	23	4.	13.	2.	1:4.5
300	24	3.	12.8	1.	1:5.1
500	27	2.	12.5	.5	1:6.8
700	26	1.8	12.5	.4	1:7.5
900	26	1.5	12.0	.3	1:8.5

Here we see as a dairy calf grows older the protein quanitity is decreased and the nutritive ratio widened. We learn by this that any animal, as it grows older, requires increasing amounts of the heat and fat formers.

NATURE WIDENS THE RATION.

Nature supplies the needed carbohydrates by creating an appetite for grass and roughage materials. In the early stages of growth a calf feeds on its mother's milk, and in a week or two begins to nibble at the grass or corn, and in this way supplies to itself what food materials that are needed to balance its own ration.

A Point in Practice.

It is common practice everywhere to change young animals from whole milk to skim milk, after a few weeks of feeding.

This is a wrong practice unless easily digested carbonaceous food is fed in connection with the skim milk. Skim milk contains no fat; consequently the young animal is robbed of this nutrient and will not thrive in a satisfactory way. Increasing the quantity will not help. Death will ultimately follow if the milk ration is not balanced with a substitute for the fat taken from the milk. The table below gives the digestible nutrients in whole and skim milk:

Feeding Stuff.	Dry Matter.	Digestible Nutrients in 100 lbs.		
		Protein.	Carbo-hydrates.	Fat.
Whole milk	12.8	3.6	4.9	3.7
Skim milk	9.6	3.1	4.7	.8

It is seen at once the great difference between whole and skim milk is the almost complete absence of fat in skim milk.

Where skim milk is used in place of whole milk, shelled corn should be used, and gradually increased as the animal grows older. The "pot-gutted" condition of calves can quickly

be changed by using shelled corn daily in connection with skim milk. This applies to pigs in the same way, wheat middlings and corn fed in connection with skim milk will make better growth, and in a more economical way.

Feeding Young Animals.

It is a simple problem to feed colts, pigs and lambs in their early stages of growth. Their mothers will take care of them provided they are fed properly themselves. Since these three classes are not robbed of their mothers' milk, they feed in nature's way; and as they grow older they add to their food supply by feeding with their mothers on the wider balanced rations. With calves, however, it is different. Their food has a great commercial value. Whole milk for the market or for butter is too valuable to feed the average calf. Consequently milk comes to them with the butter fat taken out. A practical method is to feed the new-born calf whole milk for a number of days, then gradually change the whole milk to skim milk by decreasing the one and increasing the other, mixing the two. In a week or ten days a young calf will begin to eat corn, and by the time the substitution in milk is made; and the calf has balanced its food ration by using corn instead of the butter fat in the milk.

Calf Feeds.

There are a number of specially prepared calf feeds on the market to take the place of milk. Some of these are good and perfectly satisfactory. Their one objection is the cost. A ton of prepared calf food costs from $75 to $150, and practically all the substances in the mixture are obtainable at $15 to $30 a ton. The student, by using linseed oil meal, boiled flax seed, corn and cow pea meal, etc., can himself prepare a mixture to satifactorily take the place of the butter fat in milk.

Notes on Care and Feed of the Calf:

CHAPTER XIII.

The Cost of Nutrients.

The student readily recognizes by this time the necessity of using different feeding stuffs to make balanced feeding rations. The question now arises, what method shall be followed to get the necessary feeding materials?

Little discussion is needed to present the importance of growing on the farm the bulk of the materials used. The farmer can grow the greater part of the feeding stuffs cheaper than he can buy them of some one else. This is also in line with what was said in a previous chapter, of changing what one raises (which is a raw material) into a finished product, the raw material having a small commercial value, while the finished product a value many times above the former.

By glancing back to the table showing the digestible nutrients of feeding stuffs, the student will see at once that practically all materials grown on the farm and used for feeding purposes are low in protein but correspondingly high in other nutrients. It follows, then, the farmer can raise all the carbohydrates and fat needed for either the dairy or the block.

He is interested, then, primarily in the purchase of protein.

Unfortunately there are no feeding stuffs made up wholly of protein. If there were, the balancing of rations in reference to cost would be a very simple process indeed.

Protein not Solely Purchased.

Though protein is the constituent we are after in our purchase, we are obliged to pay for other nutrients along with the protein. Carbohydrates and fat are always present in every feeding stuff and they have a commercial value. Consequently when we buy protein we also pay for carbohydrates and fat. It should not be understood here that these latter constituents are a trouble or a nuisance; they have a value. But one readily sees it is unfortunate to purchase them when their like can be secured at home. It suggests the same idea that a necktie must always be purchased with a collar. One may never wear a necktie, or he may have all he needs at home, yet every time he buys a collar he is obliged to pay for a necktie as well. If one did not need a necktie, then, but wanted the collar, he would likely get the collar having the least necktie about it and place the value of the purchase wholly upon the collar and nothing on the necktie.

It follows in the same way in the purchase of protein: If the farmer raises on his farm all the carbohydrates and fat he needs and which have a low commercial value, he can not afford to buy more of the same constituents at a price many times higher than he can raise the same for himself. Yet the feeder is obliged to do this very thing when he purchases his protein. It cannot be helped and it is no one's fault. There is a point of practical bearing, however, in this matter: If you have to take carbohydrates and fat along with your protein and pay for them, then you want to get just as little carbohydrates and fat in the feeding stuff you purchase and just as much protein as you can. You will buy the feeding stuff having the highest quantity of digestible protein that costs you the least per pound of protein.

The Uses of Protein.

Protein may be used in the body to do four things:

I. Tissue building.
II. Body fat.
III. Material for the production of heat.
IV. Material for the production of energy.

Since carbohydrates and fat furnish the last three things, and they can be raised on the

farm, it is not necessary to purchase protein, the expensive part of a food, to heat the body or keep up the energy.

"Protein," says Brooks, "is a flesh former, the machine maker, the repairer of wear and tear. It may also be used in the body as a fuel to maintain the temperature of the body, but to feed in such a way the protein must be used as a fuel is not wise, as it is too costly. Fat and carbohydrates are far cheaper fuels. The feeder who so manages that the animal must burn protein would be about as unwise as the householder who would select as fuel for his stove, mahogany or curled maple, when ordinary woods or coal would serve the purpose just as well and at much less cost."

Grouping Feeding Stuffs.

Feeding stuffs may be divided from standpoint of physical properties into two classes:

I. Roughage material.

II. Concentrates.

The first group contains all of the grasses, leguminous and coarse foods raised on the farm, such as corn stover and straw.

The second group contains the seeds and grain or some by-product of the seeds and grain of farm crops. The first is the coarse portion

of a ration, including such feeding stuffs as hay, corn fodder, roots, silage, etc.; the second is the more nutritious part consisting of oat meal, cotton seed meal, etc. The chief constituents of the first are carbohydrates and fat, or the home products; of the second protein, or the purchased product.

PRACTICAL SUGGESTION.

Plan to grow all of the carbohydrates and fat and not to purchase any; and then grow as much of the protein roughages, such as clover, cow peas and alfalfa, to make the purchased protein as little as possible.

This means economical and practical feeding.

When cotton seed meal is worth $24 per ton, what are the following feeding stuffs worth per ton or bushel on basis of digestible protein content?

Corn

Oats

Bran

Cow peas

Gluten meal

Cotton seed

Cow pea hay

Timothy hay

Cotton seed hulls

Corn stover

CHAPTER XIV.

The Cost of Nutrients.—Continued.

THE PURCHASE OF PROTEIN.

Since it is neither practical nor possible under ordinary methods of farm practice to obtain the necessary protein from the farm, it follows that it must be secured elsewhere. This is done either through purchase of grain materials not raised on the farm, or the purchase of by-products from manufacturing concerns. Bran comes from flour mills, gluten feed and meal from the manufacturing of starch, and cotton seed meal from the oil mills.

There is a long list of concentrates as the source of protein consumption. The feeder is interested in knowing which of them he shall purchase. Two things will aid him in the selection: the protein content and the market price of the feeding stuff.

A wise selection requires the two to be considered together. For instance, the following food stuffs at market prices are available to a feeder:

Corn, $25.00 per ton, or 70c. per bushel.

Oats, $35.00 per ton or 56c. per bushel.

Gluten meal, $25.00 per ton.

Cotton seed meal, $26.00 per ton.

Bran, $26.00 per ton.

Using the above as an example, which shall be selected if the feeder simply desires to get protein for purpose of balancing a ration, having as its basic constituents feeding stuffs raised on the farm?

The sensible thing to do, is to determine which food furnishes a pound of protein at least cost.

Turning back to Table IV, page 49, we find that 100 pounds of each contain the following quantities of protein:

Feeding Stuff.	Pounds of Digestible Protein.	
	In 100 Pounds.	In One Ton.
Corn	7.9	158.
Oats	9.2	184.
Gluten meal	25.8	516.
Cotton seed meal	37.2	744.
Bran	12.2	244.

The above table gives the quantity of digestible protein in each ton of the feeding stuffs named.

A ton of corn contains 158 ponnds of protein, which is worth $25.00 per ton. One pound of protein will therefore cost 2500 divided by 158, or 18 cents + per pound.

In like manner each is determined, giving us the following:

Feeding Stuffs.	Price per Ton.	Pounds Digestible Protein per Ton.	Cost per Pound Protein.
Corn	$25.00	158	18. +cents.
Oats	35.00	184	19. + "
Gluten meal	25.00	516	4.9+ "
Cotton seed meal	26.00	744	3.4+ "
Bran	26.00	244	10. + "

This table shows us at once that at prices stated, cotton seed meal and gluten meal are by far the cheapest sources of protein.

The same method is followed in determining the protein value of every food stuff. So simple is it, every feeder and stockman should make it a point to determine always the feeding values of different feeding stuffs in this comparative manner.

On Basis of Total Digestible Nutrients.

The comparative cost of digestible nutrients is determined in the same way and has just as important bearing on feeding farm animals as that of protein alone. One is obliged, we will say, to purchase some grain or concentrated feeding stuff. The best guide in the selection is the quantity of total digestible nutrients. The feeding stuff that will furnish these at the least cost per pound should be selected.

Consulting our table again, showing each of the constituents, we get the following:

Feeding Stuff.	Dgestible Nutrients in 100 Pounds.				Total Digestible Nutrients in 1 Ton.
	Protein.	Carbohydrates.	Fat.	Total.	
Corn	7.9	66.7	4.3	78.9	1578
Oats	9.2	47.3	4.2	60.7	1214
Gluten meal	25.8	43.3	11.0	80.1	1602
Cotton seed meal	37.2	16.9	12.2	66.3	1326
Bran	12.2	39.2	2.7	54.1	1082

The next table shows the price per pound of digestible nutrients when the market price per ton and total digestible nutrients are given:

Feeding Stuff.	Market Price.	Total Digestible Nutrients.	Price Per Pound of Digestible Nutrients.
Corn	$25.00	1578	1.5 cents.
Oats	35.00	1214	2.8 "
Gluten meal	25.00	1602	1.5 "
Cotton seed meal	26.00	1326	1.9 "
Bran	26.00	1080	2.4 "

This table shows that a pound of digestible nutrients is most costly in oats; and cheapest in corn, gluten and cotton seed meals; bran being medium in price. The various kinds of feeding stuffs can be determined in this manner by obtaining the market prices and dividing these prices by the quantities of total digestible nutrients of the respective feeding materials.

Necessity of Judgment in the Selection.

A mere determination of total digestible nutrients is not sufficient for a final selection. Judgment must be exercised in the selection, and the quantity of protein considered. For instance, we see that corn is slightly cheaper than bran on the basis of total digestible nutrients. Now, if it is for the dairy, we would use bran rather than corn, because the latter contains only slightly over one-half the amount of protein. Cotton seed meal contains just about five times the quantity of digestible protein that corn does, and if they could be purchased at the same prices per pound digestible nutrients, cotton seed meal would be many times more valuable than corn, because of the very much larger quantity of protein.

Roughage in Relation to Protein.

The student should be as careful in the selection of roughage materials for feeding purposes as he is in the purchase of concentrates. It is often advisable to sell one kind of feeding stuff and purchase one or more kinds in exchange.

For the dairy, for instance, protein is not only desired but necessary. Excepting for the corn belt, it is usually economy to sell corn

and oats and make an outright purchase of cotton seed meal, gluten meal and bran. In the same way one can often sell his roughage materials to good advantage and secure others that contain more of the constituents desired, and in so doing cut down the amount of concentrated foods.

If the feeder uses corn stover and timothy hay, he will necessarily be forced to balance his rations with concentrated materials. On the other hand if he uses cow pea hay and clover hay in main for roughage, the necessary grain material is small. The author is acquainted with one market where timothy hay sells for twenty dollars per ton, cow pea hay fifteen dollars, and corn hay brings twelve dollars. The student will see at once that cow pea hay is the most economical food, for it contains nearly four times as much digestible protein as timothy, and nearly six times as much as corn hay. The feeder will see at once it is to his advantage to dipose of his timothy or shredded stover and with the same money purchase cow pea hay. The saving in corn and bran or other concentrates will be clear profit to him.

On basis of protein:

When timothy hay sells for $20 per ton, what are the following worth?

Corn hay

Cow pea hay

Cotton seed hulls

Clover

Oat hay

Alfalfa

On basis of total digestible nutrients:

When timothy hay sells for $20 per ton, what are the following worth?

Corn hay

Cow pea hay

Cotton seed hulls

Clover

Oat hay

Alfalfa

CHAPTER XV.

Production of Roughage Materials.

Economy in raising live stock means the production of all roughage materials on the farm. It is possible to purchase all roughage material and yet make a financial success of growing farm animals, but it is not likely; nor is it reasonable or sensible to do so. In deciding what forage and grain crops to grow, the student should consider:

I. The crops in relation to soil and climate.

II. The crops in relation to line of business.

III. The home production of protein.

IV. The growing of crops that have power of producing greatest quantity of digestible dry matter.

V. Soil improvement in relation to crops grown.

1. *Crops in Relation to Soil and Climate.*

Farm crops are not equally adapted to all soils and climates. Cotton seed can not be produced in the north because of the cooler and shorter seasons. Timothy and blue grass are most productive in cool, limestone soils, and cow peas are more at home on warm, dry soils.

Nature has been generous, however, and has looked after the matter of crops and grasses quite carefully. If we but do our part there will be no difficulty in providing all roughage materials necessary for the successful production of livestock.

Our aim should be to make the best use of what we have; to improve by selection and care those species best adapted to our soil and climate; and by better methods of cultivation, growing and caring, secure still greater yields and better returns at the cheapest cost of production.

This does not mean we shall refuse to try new plants and endeavor to adapt them to our peculiar conditions. We should not, if they are no better than what we have. If a new plant is found of peculiar value to our environments and business, let us endeavor to bring it to our service by all means. But let us hold on to our old friends till we have tried the new and are sure the change is no mistake.

2. *Crops in Relation to Line of Business.*

A farmer necessarily becomes a specialist. He gathers those classes of animals about him which he likes best and fines most profitable. He will do the same with the crops for carrying on his business. The silo, for instance, is

necessary for the highest success in dairying. Succulent food must be furnished throughout the year. The silo, then, is the winter pasture field.

Soiling crops should be provided to supplement the summer pastures when they become dry and parched. Fattening cattle need good sized corn fields for stover and grain.

The successful farmer of to-day and of the future will have at his hand the use of crops and methods for his special, particular purpose.

The ordinary farmer will go on in the same old way and continue to say "farming does not pay."

3. *The Home Production of Protein.*

The experiment station has given us positive evidence of the importance of protein for all classes of farm animals. The gist of the matter is, we have been feeding too little protein because the ordinary farm crops are deficient in this constituent and we have found out only recently how and where it can be obtained. The discovery shows that protein costs money. To balance feeding rations properly, we have been obliged to purchase large quantities of grains and concentrates to supply the needed protein.

To bring the purchased amount of protein down to the minimum quantity is one of the most important questions before the feeder to-day. This can be done to a very great extent by growing those crops having relatively high percentages of protein, such as cow peas, clover, vetches, soja beans and alfalfa. There are a few others like these, but those named are the most important and two or more can be grown readily in every section of our country. Alfalfa, cow peas and clover have already been grown in east, south and west and long since have passed the experimental state. Following is a ration almost wholly home grown and furnishes the necessary digestible nutrients in proper quantity and proportion for a dairy cow in full flow of milk, and cost for an outside purchase less than three cents per day for each cow:

HOME GROWN RATION FOR DAIRY COW.

Feeding Stuff.	Dry Matter.	Digestible Nutrients.		
		Protein.	Carbohydrates.	Fat.
Cow pea hay, 15 lbs	13.50	1.62	5.79	.16
Corn stover, 10 lbs	5.95	.17	3.24	.07
Corn ensilage, 30 lbs	6.27	.27	3.39	.21
Cotton seed meal, 2 lbs	1.87	.74	.33	.24
Total	27.59	2.70	12.75	.68

If timothy hay had been used in place of cow pea hay, several pounds of meal and bran would have been required to furnish the protein to balance the ration, and supply the deficiency in the roughage feeding materials.

Clover and alfalfa are almost as nutritious from the standpoint of protein and can be used in the same way. Every student should consider well the bearing this fact has upon feeding principles, for with it may lay success or failure. He can at least be assured that with its practice greater profit will result.

4. *Growing Crops for the Greatest Quantity of Digestible Nutrients.*

We are prone to call a crop a crop without considering its productive capacity. This is a mistake; especially when it is not a source of protein supply. It should be our policy to grow such crops as are heavy producers. When we consider the matter in this way we see that one acre often produces as many pounds of digestible nutrients as two acres of some other crop.

The following table arranged by Dr. Jordan gives us a vivid explanation in this respect:

Feeding stuff.	Field per Acre Fresh Material.	Dry Matter.	Dry Matter per Acre.	Dry Matter Diges-tible.	Digestible Dry Matter per Acre.
	Pounds.	*Per Ct.*	*Pounds.*	*Per Ct.*	*Pounds.*
Alfalfa	35, 000	25.	8, 750	69	5, 162
Indian corn	30, 000	25.	7, 500	61	5, 025
Red clover	18, 000	30.	5, 400	57	3, 070
Oats and peas	20, 000	16. 2	3, 240	65	2, 106
Timothy	11, 500	38. 4	4, 416	57	2, 517

It is readily seen from the table that alfalfa and corn produce nearly twice as much digestible nutrients as timothy, which is of considerable importance, especially when good tillable land is not readily available.

5. *Soil Improvement in Relation to Crops Grown.*

A good farmer should always be thinking of improving his soil. This is wise not only for posterity but immediate crop production as well.

Crops that may be termed soil depleters should be grown as infrequent as possible. Since the leguminous add nitrogen to the soil and at the same time are the best sources for protein supply, it follows they should receive primary attention in every system of crop rotation. We want crops that will furnish largest quantities of needed nutrients and at the same time improve the soil. The clovers, the cow pea and alfalfa will be more extensively grown in the future and will occupy a much more important place in every system of farming.

The student will show system of rotation of crops that involve the successful feeding of some class of live stock:

CHAPTER XVI.

THE SILO AND ENSILAGE.

The silo does for live stock what fruit cans and fruit jars do for man. One knows a tomato will quickly decay if not put in the fruit jar where it can be sealed so as to prevent the entrance of the air and bacteria. The silo is a large pit that holds cut-up corn or other forage and keeps it succulent and prevents the maturity of the plant cells. The object of the silo is to keep the forage as near the green state as possible. To this fact lies the noted value of ensilage. As we like during winter an apple that has been stored away in the cellar in preference to a dried one, so will live stock relish, in a greater degree, the corn plant if kept as nearly the green state as possible. In a previous chapter we discussed the importance of palatability in a ration. No difference how nutritive a feeding stuff is, if the animal does not like it, it usually is a failure as a milk or meat producer. Of course no one claims that ensilage contains greater feeding value than the cured product. A silo has nothing about it to make more protein or carbohydrates or fat. But the juice is there, the flavor is there, and the effect of freshness and greenness.

Economy in Ensilage.

There is great economy in ensilage in the fact that a larger part of the product is eaten. The student knows that if the whole corn plant is fed, for instance, the ear and leaves are the only parts eaten. Fully half the feeding value is lost. If, however, you can put it in the silo, every particle is eaten. The feeding value is doubled in this way. The silo, then assists the feeder in taking care of a larger number of animals from an equal area.

Another point in economy lies in the storage of the feeding stuff. A silo is cheaply constructed and holds an immense quantity of forage that is always at hand where feeding is to be done. Thus the labor for winter feeding is materially lessened by the use of the silo.

Wherever high-class beef animals are raised or profitable dairying is being carried on, there the student will find the silo and its highest and best use employed.

Capacity of Silos.

The following table, by King, gives the capacity of round silos at different depths and varying inside diameters:

Feet Depth.	Inside Diameter in Feed.			
	15	18	20	25
20	58.8	84.7	104.6	163.4
21	62.9	90.6	111.8	174.7
22	67.4	96.8	119.6	186.8
23	71.7	103.3	127.5	199.3
24	76.1	109.6	135.3	211.5
25	80.6	116.1	143.3	223.9
26	85.5	123.0	151.9	237.4
27	90.2	129.8	100.3	250.5
28	95.0	136.8	168.9	263.9
29	99.9	143.9	177.6	277.6
30	105.0	151.1	186.6	291.6
31	109.8	158.2	195.6	305.1
32	115.1	165.7	204.6	319.6

Feeding Ensilage.

The quantity of ensilage fed depends somewhat on the kind of forage used. An ensilage made of clover, cow peas or alfalfa contains more protein than one made of corn. If either of the former were used, from fifteen to twenty pounds would be sufficient for a daily feed. On the other hand if corn ensilage is fed, from twenty-five to fifty pounds can be fed, thirty to forty being the average. Ensilage can be fed once or twice each day. If a small quantity is used in the daily ration the feeder can use ensilage but once; a larger quantity will require two feedings. The use of ensilage should be regular, that is, every day, so as to keep the top of the silo fed off to keep from spoiling.

One or two inches from the whole of the top will prevent any decay. Feeding in the stall should be done just after milking, otherwise the odor may be observed in the milk. The grain can be fed either in connection or just before feeding the ensilage.

Crops for Ensilage.

There are only a few crops that can be successfully used for ensilage. The great silo crop is corn; and so much so, whenever silo is spoken one invariably thinks of corn ensilage. Clover is also insiled with a fair degree of success. Peas mixed with corn are also good, and alfalfa to some extent. Any crop having a hollow stem generally makes poor silage because of the air stored with the crop. There is also little reason for using crops that are easily cured in the field, like the grasses and hays.

Digestible Nutrients in Important Ensilage Crops.

Feeding Stuff.	Dry Matter in 100 Pounds.	Digestible Nutrients in 100 lbs.		
		Protein	Carbohydrates.	Fat.
Corn ensilage	20.9	0.9	11.3	0.7
Clover	28.0	2.0	13.5	1.0
Alfalfa	27.5	3.0	8.5	1.9
Cow pea	20.7	1.5	8.6	0.9
Soja bean	25.8	2.7	8.7	1.3

Practical Notes on Feeding Ensilage:

CHAPTER XVII.

Soiling Crops.

The production of green crops to supplement summer pasture is more or less a necessity for the highest success in dairying. The milk flow can not be maintained upon withered or dry pastures. The winter feeding of dairy cows has been made a success by the use of the silo. But ordinarily ensilage is used up by the end of winter and none is left for feed during the summer. Perhaps this is better after all; a change in the feed of dairy cows is as necessary as for ourselves. It is true also that with spring comes good fresh pastures, green, succulent and nutritious. Where is a better place, then, for milch cows than in such a pasture field?

Summer feeding would be simple if the pastures remained fresh and green until ensilage comes again. We all know that with July and August comes the hot winds and dry weather, and with them dry pastures and a marked decrease in milk flow.

This can be wholly remedied by soiling crops, and at little expense to the owner. Where one

has pasture for spring and early summer feeding, the soiling problem is simple indeed.

Corn the Basis for Soiling.

No dairyman or feeder can get along without corn. It is the main crop for the silo or for soiling. It should be the practice to plant as early as weather conditions permit a small area of corn for soiling purposes. One can always select a small area that is early ready for the plow, and on this manure should be put and disked well in the soil. Application of commercial fertilizer can also be added if the soil is not as rich as it should be for the purpose. Plant the corn when the soil is thoroughly prepared and when reasonably sure frosts are over. The corn should be planted so as to produce the largest quantity of forage. For soiling purposes you are not expecting ears. A thick seeding, then, is necessary. Plant in rows 36 to 40 inches apart and a grain every 3 or 4 inches. Harrow soon after planting.to destroy weeds that are abundant at that time. Then cultivate frequently during the rest of the time. By the last of June you have green corn ready for stock. If your pastures are light, begin to feed a little corn every day and then gradually increase as needed.

As the corn is cut off, disk up the land and follow with cow peas. This can be done every two or three weeks and a crop of cow peas for soiling or hay can be obtained the same season.

A year's experience with soiling will show the feeder the great value of this practice.

Soiling to Take the Place of Pasture.

Where soiling crops are to take the place of pasture, preparation must be made the previous year. By this we mean a crop must be sown the previous fall to furnish an early crop in the spring.

Rye does this better than any other crop. It grows all winter and shoots up early in the spring aud is ready to be fed when ensilage is gone. A small acreage of rye will furnish green food for a month. By this time the clover field is ready for two to four weeks feeding. Then you can turn in the feed lot, which should be five or six acres in size for thirty or forty cattle. With a little of the clover hay that has just been made or some of the cow pea hay of last year that was provided for this purpose, to be fed in connection with the pasture in the feed lot, you are provided with green

food until the early planted corn is ready for the daily feeding.

Nothing is lost by the practice of soiling. If you have too much rye, the surplus can be cut and put in the silo and fed along during the summer; the surplus clover can be made into hay; the same of cow peas; and any excess of corn goes in the silo.

Rotation for Soiling Crops.

As soon as the rye is taken off, the rye land is plowed and planted to corn and cow peas; the early cut corn is either seeded to cow peas or to crimson clover; and all ensilage corn land sown to crimson clover; cow pea land to rye. This rotation gives us soiling crops, ensilage crops and hay crops; a leguminous crop each year to add nitrogen to the soil; and a cultivated crop each rotation to kill out weeds and to change unavailable plant food into available plant food. All manure made by the herd is added to the soil either in fall, winter or both. It must be noted a practice like this means the bringing up of the soil in a very short time.

Advantages of Soiling.

I. Smaller area needed.

Where pasturing is followed, from two to five

acres are required for furnishing necessary feeding stuffs for each animal per year. It is generally conceded by all who have followed soiling that three quarters to an acre and a half will furnish the yearly food supply for a mature animal.

II. Fewer fences needed.

The only fences needed with soiling is for the feed lots. This is a saving of land where fences would be put; a saving of capital otherwise invested in fences; and a saving in labor in keeping fences clean and repaired.

III. No food destroyed by tramping.

Cattle tramping over pasture lands not only destroy considerable food, but so compact the soil, especially during wet weather as to greatly damage the physical condition of the soil. As much as a third or half of the pastures are injured by tramping over them.

IV. Less acreage required.

If one is near a city where lands are more valuable, the investment in acres is a matter of considerable importance. The practice of soiling enables the dairyman to do on half the number of acres that would be required if pasturing were followed.

V. Soil improvement more readily obtained.

Since one needs but half the area for follow-

ing soiling methods, it readily suggests a larger quantity of manure by this system. This means farming in an intensive way that insures greater productivity of land and larger crops with each successive year.

Objections to the Practice of Soiling.

The one objection to soiling lies in extra labor in growing and feeding the crops. By pasturing, labor is needed only in taking cattle to and from the pasture fields. The necessary extra labor is, however, a matter of small importance when considered in the light of the many advantages to the system.

Soiling Best Adapted to Dairying.

While soiling may be adapted to any class of live stock, it is peculiarly a system for the dairy farmer. The food is better because of freshness and succulence; labor is always available; and the greater profits permit greater care and attention that the highest success may be attained.

Student's plan for furnishing soiling crops, hay, corn and ensilage for a herd of twenty-five cows per year:

CHAPTER XVIII.

FEEDING BREEDING ANIMALS.

It is a noteworthy fact that the excessive feeding of breeding stock is as harmful or more so than underfeeding. This is especially true when the feeding ration contains of an over-abundance of carbonaceous foods. The use of this kind of feeding stuffs for breeding animals when mature, causes them to be over-fat and not as prolific as they otherwise might be.

It should be borne in mind also, that a breeding animal must furnish material for the growing fœtus. This is blood and tissue for every part of the offspring. Carbohydrates and fat can not assist in providing this material. It comes solely from the protein of the food. It follows then each pregnant animal should receive considerable protein in its ration for its own use and that of its developing progeny.

THE COW.

The dairy cow should never be in a very fleshy condition. The production of fat cells in the body is at the expense of milk cells, and the cow with beef tendencies is not usually

a profitable milk producer. Since milk is not the object of great importance in the beef animal, bloom and flesh are desired in breeding stock for beef. The dairy cow to be profitable should be in milk for eleven months each year. The cow that "goes dry" after five or six months milking, would be better for the gambles than in the dairy herd. Two or three months preceding calving, the dairy cow or beef cow should receive daily a pound or two of wheat bran, or four or five pounds of alfalfa, clover or cow pea hay, for needed protein and ash constituents in the ration.

At Calving Time.

At calving time the dairy cow should be put off to herself. Bran, clover, alfalfa or cow pea hay, together with ensilage or some other succulent food should furnish the daily ration. When calving is over, cut off the ration for a day or so, feeding nothing but a little bran and succulent food. The quantity of food should then be increased from the second day gradually until the cow is placed on her full ration.

The beef cow usually is permitted to drop her calf in the field. Since she is placed under conditions more natural to her, she will

usually take care of herself and only needs watching to see if the calf is properly taking to its mother.

The Brood Sow.

Corn has been connected so long with hog feeding it seems to hold the high place as a food for the brood sow. But this is wrong. Food of a more protein nature should be fed the sow previous to dropping her pigs and while she is suckling them. Her food should be similar to the dairy cow in every sense of the word, so far as the grain part goes. Bran slop makes a very desirable food, and should be fed both before and after dropping her pigs. At pigging time the sow should never be disturbed, and the usually ration diminished for a day or two. Since young pigs are to be fed for some time through their mother, liberal feeding of the brood sow will always be rewarded in more healthy and quick maturing stock.

The Brood Mare.

The brood mare should be worked or exercised up to foaling time. Liberal feeding of oats and bran balanced with corn and hay will furnish a satisfactory ration for the mare before and after foaling. The same care should

be used in diminishing the food supply when the colt is born. The mother is feverish and weak at that time and should be fed only what is needed for appeasing the appetite. Like all other classes of breeding animals, the ration should be increased gradually after the offspring is born.

The Ewe.

What has been said in reference to the dairy cow is especially applicable to the suckling ewe, since, however, the first growth of lambs is chiefly from the mother's milk, there is no reason for discussion of substitutes for this food. The ewe should be given food similar in every way to that offered the dairy cow—succulent, rich in protein and palatable. This can be supplied in good clover, alfalfa, cow pea hay and concentrates similarly used for the cow. From three-quarters to a pound of grain should be given. As the lambs increase in size they will quickly begin to eat with their mothers and the same food stuffs will be eaten greedily by them.

Further notes on feeding breeding animals:

CHAPTER XIX.

Feeding Stuffs in Relation to Manure Produced.

It was suggested in the early pages of this book that an ideal agriculture maintains itself. If the feeding stuffs raised on the farm were fed to animals and the manure returned to the land, soils would not only maintain their present fertility but would become more productive. The value of manure is of great importance wherever commercial fertilizers are used. In North Carolina, over $6,000,000 of commercial fertilizer are annually purchased. Fully half of this immense amount is expended for cotton seed meal. We are taking a feeding stuff and using it as a fertilizer. It should be used first as a food for farm animals and then when it becomes manure let it go to the soil.

The business-like, economical way of buying commercial fertilizers is to take a dollar and buy cattle foods, and by feeding only about one-fourth of the food materials are used in the animal body, the remaining three-fourths passing in the excrement in a condition even more valuable than when used in the raw state.

Double Value by Feeding.

A ton of cotton seed meal is worth $20 00 for either feeding or for fertilizers. If that ton is applied to the soil, it is worth but twenty-two dollars to the user. If it is first fed to animals, the user gets twenty-two dollars returns as food. But the animal has used but one-fourth of the elements in the ton, or five dollars and fifty cents worth. There is left through feeding, sixteen dollars and fifty cents worth of manure.

The user, then, has a double profit in first using as a feeding stuff and saving the voidings as a manure as follows:

Value as a feeding stuff	$22.00
Value as a fertilizer	16.50
Total	38.50

Had this cotton seed meal simply been used as a fertilizer, there would have been a loss of sixteen dollars and fifty cents per ton.

Every feeding stuff contains plant food; some are very valuable as fertilizers, others relatively poor. If an animal is fed rich food, rich manure will be made; if poor food, then poor manure will be made. Cotton seed meal, cotton seed, cow peas, cow pea hay, etc., are of distinct value in this respect, while cotton seed hulls, corn stover and corn are relatively low.

To show the variation in fertilizing values of feeding stuffs, the following table is arranged and the valuation is made on the basis of materials found in ordinary commercial fertilizers:

POUNDS AND VALUATION PER TON.

Feeding Stuff.	Nitrogen.	Phosphoric Acid.	Potash.	Valuation.
Cotton seed meal	136	58	17	$22.08
Gluten meal	112	8	1	16.04
Wheat bran	53	58	32	11.10
Wheat middlings	53	19	13	8.71
Corn meal	36	14	8	5.92
Corn ensilage	6	2	7	1.24
Clover hay	41	7	43	7.84
Oats	41	16	12	6.88
Malt sprouts	71	27	33	12.39

This table shows that the market price of cotton seed meal and its fertilizing value are approximately the same. Consequently when this material is used as a feeding stuff, the manure is very rich in fertilizing constituents. Comparing it with corn, ton for ton, there is a difference in the manurial value of $16.16. While this factor in feeding is very important indeed, it is usually overlooked.

A POINT IN PRACTICE.

It has been shown by repeated experiments that a pound of cotton seed meal is equivalent to 1.13 pounds of corn, and that a pound of

cotton seed meal is worth 1.75 pounds of corn for fattening purposes. Taking this in connection with the above table, we will realize the immense value of the cotton seed products for feeding and manurial purposes. It teaches the student this important lesson: He can not afford to sell cotton seed and buy corn as a substitute, even though the latter is cheaper in price per ton. A loss follows both in feeding and in the manure produced.

The Need of Live Stock.

More farm animals mean a greater quantity of manure; more manure means better crops, less purchased plant food and improved soils. This is the crying need of the South.

If the raising of live stock is combined with the production of our other crops, the highest prosperity will result to the farm.

The student will calculate the value of plant food removed in the sale of the following:

A beef animal weighing 1,500 pounds:

A hog weighing 250 pounds:

A sheep weighing 125 pounds:

One ton of butter:

One ton of cheese:

One ton of milk:

One ton of cotton seed:

One ton of wheat:

One ton of cow pea hay:

What do these figures mean?

CHAPTER XX.

THE FEEDING OF POULTRY.

The various kinds of farm poultry have much to do with furnishing the food supply of the world. As the population increases, the importance of this industry will likewise increase, and the feeding of poultry become a more delicate art.

The best philosophy in feeding is to look well after the young. This applies to every class of farm animals, for when the young has been started with vigorous and healthy growth, quick maturity and economical gains follow.

FEEDING THE LITTLE CHICKENS.

One should not be in too great a hurry to feed the little chickens. A day or two can go by after hatching before feeding. When food is first given it should be of a nature to be easily digested without the aid of grit. Perhaps the best food for the early feedings is stale bread, slightly moistened with milk. Fresh bread is not desirable. In a few days ground grain can be added to the feeding ration, such as corn meal, wheat bran and wheat middlings. Sour milk or sweet milk are excellent to go with these.

At first feed often. As the young chickens increase in size, the number of feedings can be diminished and the quantity of food increased.

Green Food Needed.

Green food should be provided early. If young chickens are permitted to run in the orchards and grass yards, they will find worms and insects and peck away at the grass blades, thus getting for themselves what they need of these materials. If it is not possible to provide feeding yards, the grower should have small pens, in which are seeded rye, grasses, rape or other forage crops to furnish the necessary succulence for greatest vigor and growth.

Feeding for Eggs.

There are many wholesome foods that can be given poultry, but a careful selection of those most suited for egg production will pay.

It should be remembered that eggs are made principally of protein. Consequently the feeding ration should contain an abundance of this material. If one goes to nature to get her teachings, he finds that poultry are busy gathering seeds, grasses, worms and insects all the time.

Let man furnish these materials, then, as

much as he can. He may not have the worms and insects, but he can find on the market bone meal and green bone that become suitable substitutes for worms and bugs. Green food must also be provided in order to obtain the greatest production of eggs. It is relished by the fowls, it matters little what kind of green food it is. A small area sown to alfalfa, clover or rye and wheat will make a great deal of pasture and will show its value in the increased number of eggs produced.

The following feeding stuffs can be used with economy in feeding fowls for eggs:

Corn.	Linseed meal.
Wheat.	Cotton seed meal.
Buckwheat.	Corn meal.
Oats.	Gluten meal.
Barley.	Alfalfa.
Clover.	Beets.
Cabbage.	Rape.
Meat and bone foods.	

Feeding for Meat.

In feeding for meat a ration to produce both lean meat and fat is desired.

Corn, oats, buckwheat and barley, one or more combined, with animal meal, will furnish a safe and economical fattening ration. The animal meal should form from 10 to 20 per cent of the ration fed. Young animals, being

fed for broilers, will do most satisfactory if given exercise in the early feeding periods. As they approach the marketing period exercise can be finally eliminated. With older and mature fowls no exercise need be given. The aim should be to furnish food that is constantly relished, so as to keep the appetite keen and good. For this reason, a change in feeding stuffs is desired.

Feeding Breeding Stock.

Infertile eggs usually result when the breeding stock is too closely confined and fed foods lacking in succulent nature.

Feeding stuffs of similar nature as suggested for feeding young fowls will meet the requirements for breeding stock.

Notes on the practice of feeding poultry: